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Rural congestive heart failure mortality among US elderly, 1999–2013: Identifying counties with promising outcomes and opportunities for implementation research

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Abstract

Objective: Describe modern trends in congestive heart failure (CHF) among elderly (>65 years of age) in the United States, to identify potentially successful rural areas. Compare CHF mortality using multiple- (MCOD) versus underlying-(UCOD) cause of death data.

Methods: U.S. Centers for Disease Control and Prevention mortality files (WONDER internet site).

Results: Using MCOD data, overall mortality rates/100,000 population (and 95% confidence intervals) for CHF among persons >65 years of age (1999–2013) were 482.0 (481.2–482.8) for large central and large fringe metropolitan (LCLF) counties, 549.6 (548.6–550.7) in small and medium metropolitan (SM) counties, and 652.6 (650.9–654.0) in micropolitan and non-core, non-metropolitan (MNCNM) counties. Twenty positive deviance NCNM counties (collectively including 198,581 residents >65 years of age) had an overall CHF rate of 300.9 (275.0–326.9) in 2013. This was significantly lower than the LCLF rate for 2013 (482.0 [481.2–482.8]), and represented a reduction of 47% since 1999. Overall CHF occurrence as estimated with MCOD was 3.4-fold higher than that obtained with UCOD.

Conclusion: These data illustrate underestimation of CHF by UCOD data and the importance of correct death certification. Rural CHF mortality rates are higher than urban rates, but some positive deviance counties demonstrate that this is not inevitable. Further research is needed to understand the relative contribution of research innovation, medical care, and public health to rural-urban disparities and the relative success of positive deviance counties.

Keywords: Congestive heart failure; elderly; mortality; rural

Introduction

Despite advances in health care, the occurrence of congestive heart failure (CHF) remains high in the United States (US), and poses daunting challenges to public health. CHF has been reported to be the second leading cause of hospitalization among patients between 65 and 84 years of age, and the leading cause of hospitalization among persons ≥85 years of age [1]. Approximately one-half of patients diagnosed with CHF will die within 5 years [2]. In 2011 Medicare spent 28% of its payments on care in the last 6 months of life [3]. Therefore, caring for patients with CHF not only increases already high end-of-life costs, but also reflects the more than 50% of Medicare patients with CHF who are re-admitted within 6 months of hospital discharge [4–6].

Although Medicare hospitalization rates for CHF declined by 29.5% from 1998 to 2008, the relative decline in risk-adjusted 1-year CHF mortality rates was only 6.6% (from 31.7% to 29.6%) for the same time period [5]. Chen et al. [5] reported significant racial disparities, with lesser declines in hospitalization rates for black persons with CHF. There was significant geographic variation as well (e.g., mortality declining in 4 states, but increasing in 5 states) [5].

Rural residence may pose special problems in CHF care, even in health care systems outside the US where there is universal coverage [7, 8]. Within the US, studies have shown both an increased frequency of CHF admissions and barriers to early physician follow-up in rural areas [5, 9]. Nevertheless, several previous reports have shown that poor outcomes from various causes are not inevitable, even among high-risk populations [10–13]. Moreover, we have shown that for stroke and heart disease, reductions in mortality of ≥50% are associated with simultaneous, but not necessarily integrated advances in scientific innovation, clinical implementation, and public health [13]. The present report addresses these issues in the context of the explanatory hypotheses they have inspired systems of care for US elderly in rural areas of the US.

Methods

Mortality data were obtained from the publically available WideRanging ON-line Data for Epidemiologic Research (WONDER) internet site provided by the US Centers for Disease Control and Prevention (National Center for Health Statistics) [14]. The Baylor College of Medicine Institutional Review Board considers such public data to be exempt from review. Except for comparative purposes, we used multiple cause of death (MCOD) data instead of the compressed mortality file (CMF). CMF and MCOD are national, county-level mortality data based on death certificates for US residents. Each death certificate contains a single underlying cause of death and up to 20 additional contributory causes. Typically, the certification of these causes is done by the physician who attends the death. CMF data is based on the underlying cause of death. MCOD data specifies the underlying cause of death, but also includes contributory causes. We used MCOD, in part because it has been observed that methods relying on determination of a single underlying cause of death among the elderly may yield underestimates of the extent to which multiple problems contribute [15]. Moreover, instructions for completing death certificates state that when system failures, such as CHF, are listed, the system failure must be immediately followed by the etiology [16]. Death certificates which simply identify CHF as the underlying cause of death are considered coding errors. To document differences in reporting frequencies between MCOD and CMF data, we compared rates of occurrence for CHF when listed as an underlying cause of death (Compressed Mortality Data – International Classification of Diseases [10th edition] codes I150 [CHF], I111.0 [hypertensive heart disease with CHF], I113.0 [hypertensive heart and renal disease with CHF], and I113.2 [hypertensive heart disease with both CHF and renal failure]) and when listed anywhere on the death certificate (specified as the combined appearance of the aforementioned ICD-10 codes and any other ICD-10 code – MCOD data).

Because information on Hispanic or Latino ethnicity (Hispanic) is not available before 1999, we restricted our descriptions to the 15-year period between 1999 and 2013, the most recent years for which data is available. Methods used for calculating age-adjusted rates (year 2000 standard population), 95% CIs, and for classifying urbanization are available from the WONDER site. In the present descriptions, urbanization follows the National Center for Health Statistics classification (large central and large fringe metropolitan [aggregated here as LCLFM], small and medium metropolitan [SMM], small metropolitan [SM], micropolitan [non-metropolitan] and non-core-non-metropolitan [MNCNM]; version of 2013) [8, 17]. To assure stable rates per National Center for Health Statistics criteria, we restricted these descriptions to places with at least 20 cases (deaths) in the numerator of each rate.

A two-step process was used to identify potentially successful positive deviant counties. First, MCOD data for 2013 were used to identify MNCNM (rural) counties in which the overall CHF mortality comprised the lowest 2.4% of the 781 MNCNM counties based on a log normal transformation of the rates (skewness =0.05) with StatsDirect software (StatsDirect 2.7.9; StatsDirect, Ltd., Cheshire, UK). These data were defined as potentially successful positive deviants. Although the 2.4% criterion would have yielded 19 of the 781 MNCNM counties, the rate for the county with the 19th highest rate equaled that for the county with the 20th highest rate, thus both were included. We then tracked the yearly rates for overall CHF mortality among persons >65 years of age in these counties, along with comparable data for all LMLFM, SM, and MNCNM counties from 1999 to 2013. The percent change in overall CHF mortality among persons >65 years of age for each group (year 2 [2013] – year 1 [1999])/(year 1 [1999]*100) was then calculated for each group.

Results

CHF mortality according to demographic factors

Figure 1 shows the age-adjusted rates of CHF as recorded in MCOD data for non-Hispanic elderly persons (>65 years of age) in the US according to US Census-defined categories of race (Asian or Pacific Islander, American Indian or Alaska Native, black or African American, or white), gender (male or female), and urbanization (LCLFM, SM, or MNCNM). Fig. 2 shows the same types of rates for Hispanic residents. Overall, the rates were highest among non-Hispanic blacks or African Americans (blacks), followed by non-Hispanic whites and Hispanic whites. Within each group, rates were higher among men. Interestingly, the Hispanic advantage, which is present for other groups, is not apparent among Hispanic Asian and Pacific Islanders residing outside LCLFM areas. Regardless of race, gender, or ethnicity, the rates were highest in MNCNM counties.

Comparing compressed (underlying cause of death) and multiple causes of death data

Table 1 presents a comparison of MCOD and CMF data for non-Hispanic and Hispanic blacks and whites according to levels of urbanization. Although general patterns are similar (e.g., the rural rates are highest), the rates and total numbers of deaths are 3.4-fold lower when CMF data is used.

Geographic variation in CHF mortality

Table 2 shows the age-adjusted mortality rates and 95% CIs among the elderly according to race (black or white), gender, ethnicity (Hispanic or non-Hispanic), and US census division. The highest (boldface italics) and lowest (boldface) divisions are noted for each demographic category. With the exception of

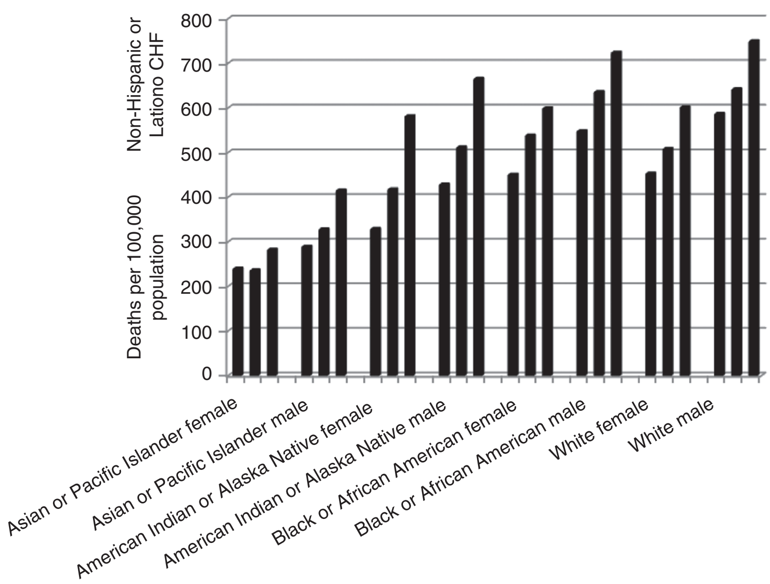

Fig. 1. Non-Hispanic or Latino congestive heart failure occurrence at death (age-adjusted, 65–85+ years) according to race, gender, and urbanization (large central and large fringe metro, middle and small Metro, and non-core, non-metro). Multiple causes of death data, US, 1999–2013.

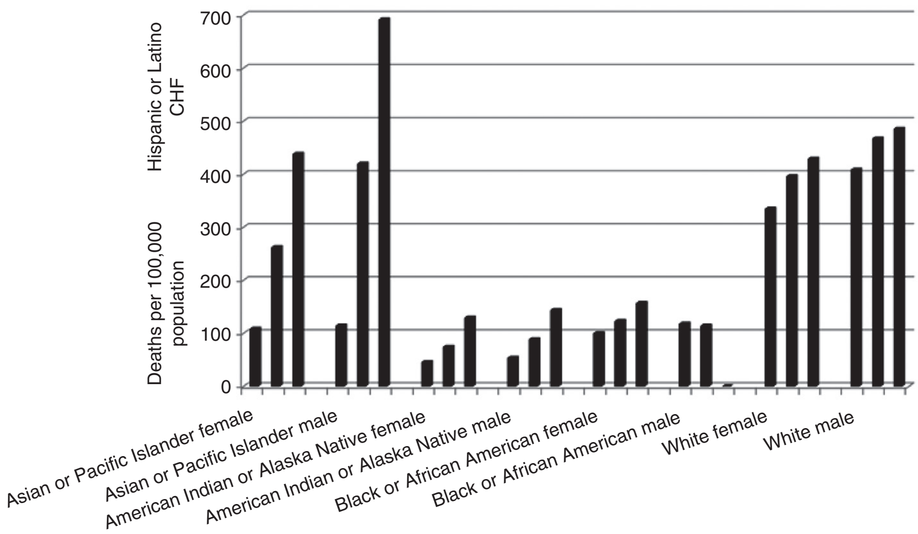

Fig. 2. Hispanic or Latino congestive heart failure occurrence at death (age-adjusted, 65–85+ years) according to race, gender, and urbanization (large central and large fringe metro, middle and small metro, and non-core, non-metro). Multiple causes of death, US, 1999–2013.

Hispanic black women (for whom the South Atlantic Division had the highest rates), either the East South Central Census Division (Alabama, Kentucky, Mississippi, and Tennessee) or the West South Central Census Division (Arkansas, Louisiana, Oklahoma, and Texas) had the highest rates. The highest and lowest census divisions were more variable for other demographic groups.

Identifying potentially successful rural counties

Figure 3 depicts the county level age-adjusted CHF mortality among non-Hispanic elderly whites in 1911 counties according to urbanization for the year 2013. The figure shows that even though MNCNM counties had the highest overall CHF rates, there were counties within this high-risk group in which the race-specific rates were equivalent to the lowest rates among LCLFM counties. Comparable results were not detected for non-Hispanic blacks or Hispanic whites (data not shown).

The 20 potentially successful positive deviant MNCNM counties were distributed across the US as follows: Baxter, AR; Monroe, FL; Whiteside, IL; Clinton and Jasper, IA; Reno, KS; Madison, KY; St. Landry Parish, LA; Talbot, MD; Newaygo, MI; Winona, MN; Flathead and Gallatin, MT; Douglas, NV; Grafton, NH; Greene, NY; Moore, Transylvania, NC; Greenwood, SC; Llano and Walker, TX; Pittsylvania, VA; Shenandoah, VA; and Door, WI. In 2013, a total of 198,581 people >65 years of age resided in these counties, equal to 2.5% of the 7,994,277 people >65 years of age residing in comparable rural areas. Sixteen of the counties were in the micropolitan group, although four (Newago, Greene, Shenandoah, and Door) were non-core, non-metro. Overall, 56% of the rural counties were in the micropolitan group. Further delineation of individual or contextual features of these counties is beyond the scope of the present report.

Figure 4 depicts the yearly time course of overall, age-adjusted (>65 years of age) CHF mortality in the 20 potentially successful positive deviant counties, as well as comparable data for overall CHF mortality in the LCLFM, SM, and MNCNM counties. Although the 20 potentially successful positive deviant counties began the observation period (1999) with an overall rate (569.0 [530.5–607.6]) approximating that of the LMLFM counties (580.2 [576.2–607.6]), the rate was 300.9 (275.0-326.9) in 2013, a reduction of 47%. LMLCM counties, in contrast, were 442.9 (439.2–446.1) in 2013, a reduction of 24%. Corresponding changes for SM counties were from 600.7 (603.7–613.7) in 1999 to 498.6 (494.6–502.6) in 2013 (an 18% reduction), and for MNCNM counties from 720.4 (713.7–727.1) in 1999 to 583.1 (577.4–588.7) in 2013 (a 19% reduction).

Table 1. Differences in congestive heart failure reported mortality rates between compressed mortality and multiple causes of death files among persons ≥65 years of age according to race, gender, Hispanic origin, and urbanization, US, 1999–2013

Race, Gender, Hispanic origin	Urbanization	Compressed mortality file		Multiple causes of death	
		Age-adjusted rate	95% CI	Age-adjusted rate	95% CI
NHBF	Large central/Fringe metro	151.8	150.1–153.6	448.8	445.8–451.9
	Medium/Small metro	190.4	187.1–193.6	536.5	531–542
	Micro/non-core (non-metro)	231.7	226.8–236.5	597.4	589.6–605.3
NHBM	Large central/Fringe metro	169.7	167.1–172.4	546.3	541.5–551
	Medium/Small metro	202.6	197.8–207.3	634	625.7–642.3
	Micro/Non-CORE (non-metro)	256.1	249–263.3	722.2	710.2–734.2
NHWF	Large central/Fringe metro	138.4	137.8–139	451.2	450.1–452.3
	Medium/Small metro	157.3	156.5–158.1	506.7	505.3–508.1
	Micro/Non-core (non-metro)	187.3	186.3–188.4	600.1	598.1–602
NHWM	Large central/Fringe metro	169.7	167.1–172.4	585.2	583.5–586.8
	Medium/Small metro	161.8	160.8–162.8	640.3	638.2–642.3
	Micro/Non-core (non-metro)	193.7	192.3–195.2	747.7	744.8–750.5
HWF	Large central/Fringe metro	89.7	88–91.4	334.8	331.5–338.1
	Medium/Small metro	107	103.9–110.2	396	390–402
	Micro/Non-core (non-metro)	132	125.5–138.5	429.2	417.5–440.8
HWM	Large central/Fringe metro	97.7	95.4–100	408.4	403.7–413.1
	Medium/Small metro	110	106.1–114	467.1	459.2–475.1
	Micro/Non-core (non-metro)	131.9	124.2–139.7	485.6	470.9–500.3
Overall		155.0	154.7, 155.3	535.5	534.9, 536.0
Total deaths		906,511		3,113,172	

HWF, Hispanic white female; HWM, Hispanic white male; NHBF, non-Hispanic black female; NHBM, non-Hispanic black male; NHWF, non-Hispanic white female; NHWM, non-Hispanic white male.

Table 2. Congestive heart failure mortality among persons 65+ years of age according to race, gender, Hispanic origin, and US Census Division,* US, 1999–2013

Race, Gender, Hispanic Origin†	Census division‡	Deaths	Population	Age-adjusted rate	Lower 95% CI	Upper 95% CI
AI/AN	Mountain	43	49223	**106.8**	77	144.4
F, H/L	Pacific	95	138999	**76.3**	61.6	93.4
	New England	94	27030	**368.6**	297.5	451.5
AI/AN	Middle Atlantic	180	80791	230.7	196.9	264.5
F	East North Central	459	109988	460.5	418	503.1
Not H/L	West North Central	691	113794	***698.7***	645.8	751.6
	South Atlantic	553	167991	383.1	350.9	415.3
	East South Central	94	38353	278.5	224	342.3
	West South Central	1348	298590	504.9	477.8	532
	Mountain	1203	349869	391.4	369.1	413.7
	Pacific	1438	298312	549.8	521.1	578.5

Table 2. (continued)

Race, Gender, Hispanic Origin†	Census division‡	Deaths	Population	Age-adjusted rate	Lower 95% CI	Upper 95% CI
AI/AN	Mountain	27	42884	**88.9**	56.9	132.2
M, H/L	Pacific	86	110180	**97.4**	77.1	121.4
AI/AN	New England	66	22498	355.5	271.3	457.6
M	Middle Atlantic	113	55465	**237**	191.8	282.3
Not H/L	East North Central	319	81350	553.8	488.5	619.1
	West North Central	575	86641	**884.3**	805	963.6
	South Atlantic	387	134216	404.6	360.8	448.4
	East South Central	65	34222	251.6	190.1	326.8
	West South Central	1075	235338	608	569.2	646.8
	Mountain	966	259103	468.6	438.1	499.2
	Pacific	1278	243159	705.9	664.8	747
A/PI	East North Central	21	9536	**290.3**	179.7	443.8
F, H/L	Pacific	194	103021	**220.4**	189.2	251.7
A/PI	New England	349	258426	**168.9**	150.9	186.8
F	Middle Atlantic	2114	1478133	177.4	169.7	185
Not H/L	East North Central	1004	657203	195.9	183.6	208.2
	West North Central	325	188235	222.4	197.8	247.1
	South Atlantic	1195	1003847	166.4	156.7	176
	East South Central	167	100817	245.4	206.3	284.5
	West South Central	926	528765	241.1	225.1	257.1
	Mountain	582	423196	183.4	168.2	198.6
	Pacific	15580	5950014	**269.2**	264.9	273.4
A/PI M, H/L	Pacific	201	72810	**354.4**	304.3	404.6
A/PI	New England	279	213278	186.7	163.9	209.5
M	Middle Atlantic	1657	1219726	194.8	185	204.6
Not H/L	East North Central	782	516994	234.4	217.1	251.8
	West North Central	212	138916	218.5	187.4	249.6
	South Atlantic	921	776739	**185.6**	172.8	198.5
	East South Central	108	69510	275.1	219	331.2
	West South Central	694	413536	253.6	233.3	273.8
	Mountain	463	288840	230.4	208.4	252.3
	Pacific	13764	4377173	**357.2**	351.2	363.2
B/AA	New England	26	48646	**69.4**	44.9	102.5
F	Middle Atlantic	291	399192	81.3	72	90.7
H/L	East North Central	42	35429	131.4	94.3	178.3
	South Atlantic	238	165606	**159.3**	139	179.6
	West South Central	55	41460	149	112.2	193.9
	Pacific	66	77340	96.4	74.4	122.9
B/AA	New England	2030	583318	**361**	345.2	376.7
F	Middle Atlantic	18984	4962261	386.7	381.2	392.2
Not H/L	East North Central	22505	4578551	498	491.5	504.5
	West North Central	4138	820335	507.9	492.4	523.5
	South Atlantic	42212	9583734	443	438.7	447.2

Table 2. (continued)

Race, Gender, Hispanic Origin†	Census division‡	Deaths	Population	Age-adjusted rate	Lower 95% CI	Upper 95% CI
	East South Central	19077	2904663	***630.4***	621.4	639.4
	West South Central	20572	3511641	584.6	576.6	592.6
	Mountain	1318	401841	364.4	344.6	384.2
	Pacific	12075	2022698	600.8	590.1	611.6
B/AA	Middle Atlantic	188	252587	**101.2**	86.2	116.2
M	East North Central	37	25639	***183.2***	126.1	257.3
H/L	West South Central	135	119455	146	120.4	171.7
	Mountain	34	29882	136.2	93.2	192.3
	Pacific	53	54529	118.2	87.4	156.3
B/AA	New England	1307	375450	428	403.9	452
M	Middle Atlantic	11340	2920059	464.4	455.5	473.2
Not H/L	East North Central	15030	2955396	596.8	587	606.6
	West North Central	2681	531869	610.8	587	634.7
	South Atlantic	27220	6061715	548.3	541.6	555.1
	East South Central	11789	1778061	***762.7***	748.7	776.8
	West South Central	13041	2267540	677.5	665.6	689.4
	Mountain	964	329179	**374.6**	349.2	399.9
	Pacific	8673	1458693	715.9	700.3	731.4
W	New England	936	354863	**304.5**	284.8	324.2
F	Middle Atlantic	6819	2438684	311	303.6	318.4
H/L	East North Central	2330	922711	296.6	284.4	308.7
	West North Central	590	223914	286.1	262.9	309.2
	South Atlantic	9146	3674319	253.5	248.3	258.7
	East South Central	210	109910	205.9	178	233.9
	West South Central	15315	4046887	***420.6***	413.9	427.3
	Mountain	6145	1940270	356.8	347.9	365.8
	Pacific	21078	5521739	418.9	413.2	424.5
W	New England	91804	16047146	451.8	448.8	454.8
F	Middle Atlantic	236959	40507647	469	467.1	470.9
Not H/L	East North Central	295779	45940537	542.7	540.7	544.7
	West North Central	141168	22076327	506.9	504.2	509.6
	South Atlantic	234627	51958448	409.1	407.5	410.8
	East South Central	112985	17214138	***615.8***	612.2	619.4
	West South Central	152943	24293171	572.3	569.4	575.2
	Mountain	75972	16829138	**418.5**	415.5	421.5
	Pacific	216906	32487942	554.6	552.3	557
W	New England	642	243784	**334.3**	307.4	361.2
M	Middle Atlantic	4719	1611560	378.8	367.6	390.1
H/L	East North Central	1983	759875	337.9	322.4	353.4
	West North Central	524	187783	346.9	316.4	377.3
	South Atlantic	6657	2623787	307.8	300.2	315.3
	East South Central	164	93795	226	190.5	261.6
	West South Central	12267	3017168	***507.6***	498.4	516.9

Table 2. (continued)

Race, Gender, Hispanic Origin†	Census division‡	Deaths	Population	Age-adjusted rate	Lower 95% CI	Upper 95% CI
	Mountain	4967	1541879	412.7	400.8	424.5
	Pacific	16809	4069620	509.7	501.8	517.6
W	New England	64181	11421932	597.1	592.4	601.7
M	Middle Atlantic	165635	28645808	608	605.1	611
Not H/L	East North Central	208969	33262978	693.7	690.7	696.7
	West North Central	100654	16282299	661.1	657	665.2
	South Atlantic	181896	40081807	513.5	511.1	515.9
	East South Central	77235	12590140	***746.9***	741.5	752.2
	West South Central	113425	18444854	713.5	709.3	717.7
	Mountain	61797	13948154	**517**	512.9	521.1
	Pacific	174630	25212686	732.7	729.3	736.1

*Places with reliable rates (>20 deaths).

†AI/AN, American Indian or Alaska Native; A/PI, Asian or Pacific Islander; B/AA, Black/African American; W, White; F, Female; M, Male; H/L, Hispanic or Latino.

‡Census Division: 1 = New England division: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; 2 = Middle Atlantic division: New Jersey, New York, and Pennsylvania; 3 = East North Central division: Illinois, Indiana, Michigan, Ohio, and Wisconsin; 4 = West North Central division: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota; 5 = South Atlantic division: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia; 6 = East South Central division: Alabama, Kentucky, Mississippi, and Tennessee; 7 = West South Central division: Arkansas, Louisiana, Oklahoma, and Texas; 8 = Mountain division: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; and 9 = Pacific division: Alaska, California, Hawaii, Oregon, and Washington.

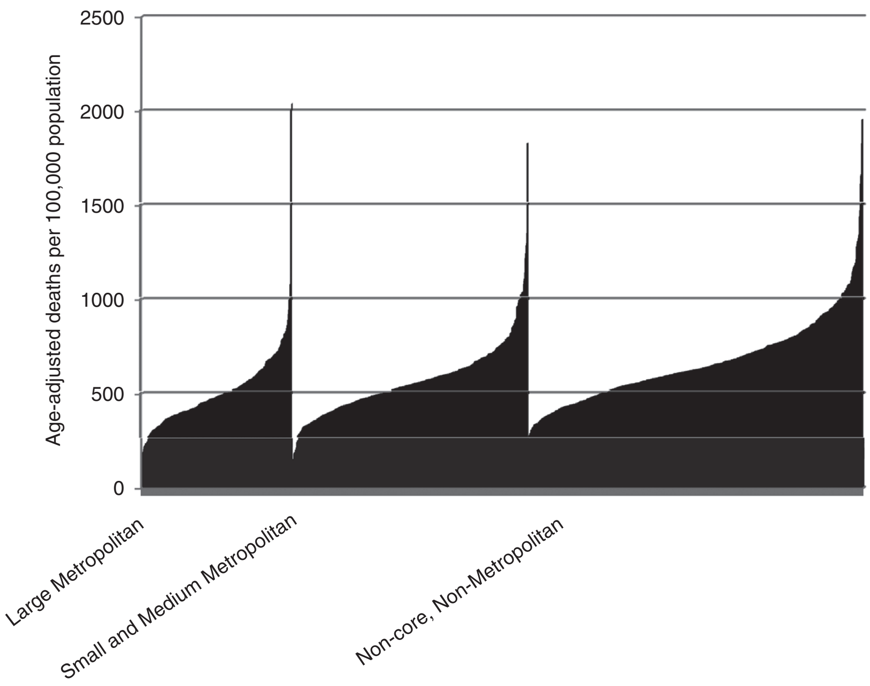

Fig. 3. Occurrence of congestive heart failure at death. Non-Hispanic white rates (age-adjusted, 65–85+ years) 1911 counties, US, 2013.

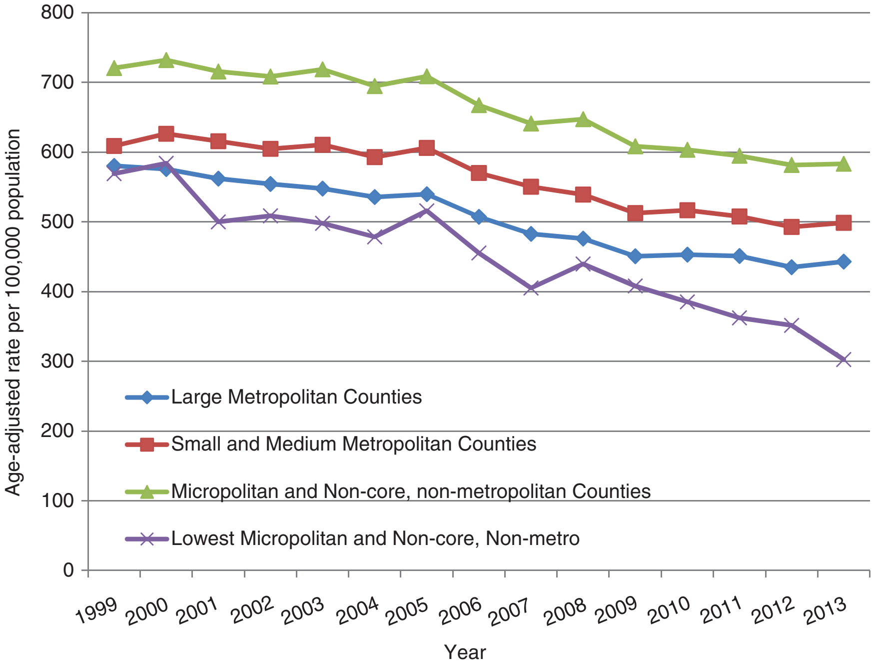

Fig. 4. Overall congestive heart failure as a contributory cause of death among US elderly (65+ years). Large metro, (n=349) medium/small metro (n=552), non-metro (n=781), and lowest micropolitan and non-core, non-metro (n=20) counties, 1999–2013.

Discussion

Within the generally high-risk population residing in micropolitan and non-core, non-metro (rural) US counties, these data identified a small subset of counties in which the risk was significantly lower than the lowest risk group based on urbanization (i.e., LCLFM counties). Moreover, this subset of rural counties experienced a decline in the overall occurrence of CHF of 47% between 1999 and 2013. We have previously shown that reductions in US mortality of 50% and higher from a variety of causes during the second half of the twentieth century are likely associated with simultaneous, if not necessarily integrated successes in scientific research, clinical implementation, and public health [13]. Because the present potentially successful positive deviant group reached a 47% mortality reduction in only 15 years, we believe that these descriptive data are consistent with the hypothesis that comparable concurrent successes may also be operative in these relatively low-risk rural counties. Moreover, because the aforementioned successes took place even as potentially negative factors, such as income inequality increased [18], there is reason to hypothesize further that the causes of community success with CHF may not necessarily be the simple opposite of adverse community progress. Analytic epidemiologic research designed *a priori* to test these hypotheses and link the outcomes to specific policies might provide important insight for policy makers.

Studies of rural successes in CHF are sparse. Nonetheless, Wu et al. [19] noted longer adverse event-free survival for CHF in some rural settings. The reasons for the protective effect were unclear. Another investigation showed that hospitals in urban areas had similar mortality rates for CHF admissions when compared with hospitals in more geographically remote areas. Specifically, risk-standardized mortality rates for heart failure hospital admissions were not significantly different in urban areas than large rural areas (p=0.92), small rural areas (p=0.84), or remote small rural areas (p=0.42). The investigators suggested that this could reflect a better capacity to provide care for conditions not requiring intensive management in rural areas. Further, the authors speculated that this may reflect equal or better capability for providing care in rural areas for conditions that do not require intensive management, possibly because patients' personal primary care physicians may be more likely to provide in-patient care, where their familiarity with medical history could shorten time to diagnosis, treatment, and discharge [20]. The comparability of such results, which conflict with the present data, is unclear, in part because the present results are population-based.

Although highlighting potential rural successes, the overall results in these data confirm previous reports reflecting rural disadvantages in CHF outcomes [5, 7–9]. In part, this may reflect limited access to resource-intensive programs found in major urban medical centers [21]. Lower densities of cardiology specialists may also be a factor because nearly 50% of cardiologists are concentrated in regions that have only 25% of the Medicare population, and approximately 60% of this population has access to approximately 38% of cardiologists [22]. Finally, poorer quality health care in rural safety net hospitals may also play a role [23].

Our findings are consistent with previous reports that blacks are at a significantly higher risk of death from CHF [24]. Our results showed that non-Hispanic black death rates exceeded the death rates for non-Hispanic whites, although the rates for Hispanics were lower than the death rates for non-Hispanics with the possible exception of Hispanic Asian or Pacific Islanders residing outside LCLFM counties. The increased risk of heart failure among racial and ethnic minorities has been linked to the prevalence of comorbidities, such as hypertension and diabetes mellitus, which in combination with socio-ecologic and bio-behavioral factors may largely explain disparities in heart failure outcomes [24–26]. Young black men may be at especially high risk [27]. In contrast, the observed relatively low rates of CHF mortality among most Hispanic populations in these data may support the concept of the "Hispanic paradox" [28].

Finally, the present results illustrate that reliance on data based on assignment of CHF as the underlying cause of death may lead to underestimates of how often CHF contributes to mortality. Primary care physicians and others responsible for completing death certificates as well as researchers who analyze the data need to be aware of this. For example, because CHF is regarded as a system failure derived from a more specific problem (e.g., cardiac valve dysfunction) it is currently unacceptable to designate CHF as the "underlying cause of death" on US death certificates. For researchers, MCOD data provides more valid estimates of CHF contribution to mortality.

The present data have limitations of death certificate data in general [29], and multiple causes of death data in particular [30]. In addition, there is a lack of patient level information [31]. The experience of potentially successful positive deviant counties in the present could reflect basic differences in the characteristics of people residing in the positive deviant counties rather than infrastructure or policy factors. It is also possible that there are coding differences which explain the apparent successes. Despite these limitations, however, we believe the present results are useful, particularly with respect to identifying places where barriers to successful rural outcome for CHF may have been met with greater success. Finding pathways to eliminate geo-social variations in heart failure, including urban-rural differences, may assist in efforts to eliminate racial disparities as well. Furthermore, additional research will support primary care clinicians, public health professionals, and others who are interested in developing successful interventions, prevention programs, and services specifically targeted at risk burdens in these vulnerable populations. Based on previous US experience [13], there may be reason for optimism if sustained and balanced successes in implementation science, primary care, and public health are achieved.

Conflict of interest

The authors declare no conflict of interest.

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